Issued April 17, 1915.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE KANSAS STATE AGRICULTURAL COLLEGE, H. J. WATERS, PRESIDENT; KANSAS AGRICULTURAL EXPERIMENT STATION, E. H. WEBSTER, DIRECTOR; W. M. JARDINE, AGRONOMIST.

SOIL SURVEY OF MONTGOMERY COUNTY, KANSAS.

BY

F. V. EMERSON AND C. S. WALDROP.

HUGH H. BENNETT, INSPECTOR, SOUTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1913.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1915.

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SOIL SURVEY.

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J. W. MCKERICHER, *Secretary.*

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., September 20, 1914.

SIR: In continuance of the soil-survey work in Kansas, which is being carried on in cooperation with the State, a survey was made of Montgomery County during the field season of 1913. The selection of this area was made after conference with the State officials.

The report and map covering this survey are transmitted herewith. I have the honor to recommend that these be published as advance sheets of the Field Operations of the Bureau of Soils for 1913, as authorized by law.

Very respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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SOIL SURVEY OF MONTGOMERY COUNTY, KANSAS.

By F. V. EMERSON and C. S. WALDROP.

DESCRIPTION OF THE AREA.

Montgomery County, Kans., is situated in the lower tier of counties and in the southeastern part of the State, being the third county from the southeastern corner. It is bounded on the north by Wilson County, on the east by Labette County, on the west by Elk and Chautauqua Counties, and on the south by Nowata and Washington Counties, Okla. It is almost square, with dimensions of 24 miles, approximately, east and west, and 26 miles north and south, and embraces an area of 644 square miles, or 412,160 acres.

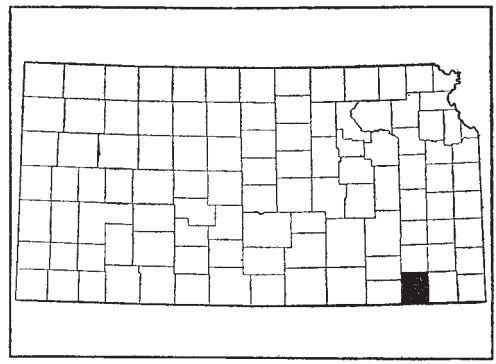

FIG. 1.—Sketch map showing location of the Montgomery County area, Kansas.

Montgomery County is included in the region known as the Osage Prairies, in the eastern part of the general region of the Prairie Plains. The general features of the Osage Prairies are a succession of westward-sloping plains separated by eastward-facing steps or escarpments, a sort of huge stairway rising westward. In front of each escarpment are hills or outliers, formerly a part of the escarpment, which have been separated from it by erosion. Thus, for example, Table Mound, northwest of Independence, marks a former position of the limestone escarpment, now lying several miles farther west.

These features are due to long-continued erosion of rocks of varying hardness which dip westward, overlying one another, somewhat like shingles on a roof, and present their outcropping edges along northeast-southwest belts (fig. 2). The rocks consist of shales, limestones, and sandstones interbedded with one another, and since the limestones are somewhat more resistant to erosion than the adjacent shales, the thicker limestones make up most of the pronounced escarpments. Some of the sandstones are weak and easily eroded,

while others, especially in the western part of the county, are resistant and make high country.

Looking at the country more in detail it is seen that, roughly speaking, there are two divisions, the eastern, relatively low and smooth, and the western, which is higher and rougher (fig. 2). These divisions correspond closely to the underlying rock on one hand and to the activity of erosion on the other; where the relief is considerable and steep slopes give streams a rapid flow the country is markedly cut into hills and valleys or, as the geologists express it, is strongly dissected.

In the southeastern part of the county is an area underlain by the Parsons formation of limestones and shales which have weathered to undulating plains. Overlying this is the Coffeyville formation, which extends in a belt about 6 miles wide from Coffeyville to the northeastern corner of the county. For the most part the rocks are weak shales which weather easily and afford the undulating country from Cherryvale to Coffeyville. Near the western edge of this undulating plain and extending from north of Cherryvale nearly to Liberty is a series of hills or outliers which are a characteristic feature of the Osage Plains.

Next overlying is the Wilson formation, composed of a complex series of shales, sandstones, and limestones, which outcrop in a northeast-southwest belt about 16 miles wide. The limestones and shales in this formation thin out to the southward, where the formation becomes more sandy and gives rise to the "sandstone country" extending from Tyro, through Jefferson, to the Verdigris River. The country in the northern part of this belt is rolling and undulating where underlain by shales and usually rather hilly where underlain by limestone and sandstone. The upper member of this formation is the Piqua limestone, which underlies eastern Louisburg and western Sycamore Townships in a belt about 8 miles wide, but about 3 miles southeast of Elk this limestone narrows and thins and extends in a narrow, discontinuous belt nearly to Caney. Erosion on the broad area of this limestone has produced a fine example of what geologists term a "dip plain," because the plain surface slopes at about the same angle as the dip of the underlying rock. This limestone dip plain, beginning at about the latitude of Crane, slopes gently westward with the dipping underlying limestone until it meets the sandstone escarpment in the central part of Louisburg Township.

At the eastern edge of this limestone plain is a much dissected escarpment locally called the "Limestone Hills." A line of outliers similar in origin to those described in the eastern part of the county, but larger and higher, extends from the hills north of Sycamore, through Table Mound, Walker Mound, Round Mound, and similar hills extending into Oklahoma. Plate I, figure 1, shows the con-

formation of Table Mound and the stretch of country lying between it and Walker Mound.

The upper and youngest formation in the county is the Buxton, which is largely of sandstone, and underlies a country that rises sharply from the eastern prairie to an average height of between 900 and 1,000 feet. In marked contrast to the topography to the east this country seems almost mountainous, for it is eroded into high rounded hills and deep valleys. Many of these valleys, for example, Circle Valley south of Elk, are partly filled by the inwash of colluvial material from the valley sides.

Most of the county is drained by the Verdigris River and its main tributary, Elk River. The main streams and their principal tributaries flow in flat-bottomed valleys which have been partly filled with alluvial materials. (See Pl. I, fig. 2.) In the sandstone country in the western part of the county and in the hilly areas in general the valleys are wide, deep, and have a general V shape. The slight fall in the main streams, especially of the Elk and Verdigris, makes them unable to carry the flood waters, so that floods are not uncommon.

The territory included in Montgomery County had only a few settlers in the early sixties, but the population increased rapidly, and in 1869 the county was organized from Wilson County. The county was in the Osage Indian Reservation, and at first there was some uncertainty as to land titles, but this was overcome by a treaty with the Indians, who were removed in 1870. The panic of 1873, followed by the grasshopper plague in 1875, caused considerable hardships and some loss of population, but, with these exceptions, settlement continued actively through the seventies and eighties. A notable development came with the discovery of oil and gas in the nineties. At first oil was mainly sought, considerable gas being wasted, but about 1900 the cheap gas began to attract factories, and now the county has a large output of manufactured articles, including cement, clay products, and zinc. A few years ago pipe lines were completed for supplying gas to Kansas City and other cities.

According to the census, the population of Montgomery County in 1890 was 23,104, while in 1910 it was 49,474, showing a gain of over 100 per cent. The two largest cities in the county are Independence, the county seat, with a population of 10,480, and Coffeyville, with 12,687, both of which have important refineries and brick, tile, cement, and other factories. Cherryvale, population 4,304, has refineries, brick plants, and an extensive zinc-reducing plant. There are also zinc works at Caney, which has a population of 3,597. Dearing, Elk, Liberty, and Havana are thriving villages.

Transportation facilities are excellent. The Missouri Pacific Railroad reaches the region around Elk and connects Independence, Coffeyville, and Caney. The Atchison, Topeka & Santa Fe runs

from Cherryvale through Independence and Havana, with branches to Caney, Elk, and Coffeyville. The St. Louis & San Francisco Railroad crosses the northeastern part of the county, and the Missouri, Kansas & Texas Railroad the southeastern corner. A trolley line connects Coffeyville, Independence, and Cherryvale with Parsons and carries milk and truck in addition to passengers. There are numerous loading stations and few farms are more than 5 miles from a railroad. Besides the local markets there is easy access to the markets of Kansas City and the zinc region of southwestern Missouri. As over half the population of the county resides in cities and towns, thousands of men being employed by the factories, there is a good demand for all kinds of farm produce, especially truck and fruit. Most of the wheat and beef cattle are shipped to the Kansas City market.

In general the public roads are in good condition. The roads through the regions of clay soils are dragged in places after each rain and this practice should be general in order to keep the roads in good condition. The rural free delivery of mail extends to all parts of the county and the majority of farm homes have telephone connections.

CLIMATE.

The climate of Montgomery County belongs to the type known as continental, and is characterized by hot summers, cold winters, and moderate rainfall. The following table gives the normal monthly, seasonal, and annual temperature and precipitation and the average dates of first killing frost in fall and last in spring, as recorded by the Weather Bureau station at Independence:

Normal monthly, seasonal, and annual temperature and precipitation at Independence.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
December	35.9	75	−11	1.93	0.79	0.28	2.6
January	31.8	75	−20	1.56	1.54	1.13	3.2
February	35.1	78	−23	1.99	0.47	5.71	2.9
Winter	34.3	.....	.....	5.48	2.80	7.12	8.7
March	46.5	98	5	2.46	1.46	4.18	1.0
April	58.9	95	17	3.68	2.02	4.70	0.1
May	67.5	99	29	4.81	3.92	5.79	0.0
Spring	57.6	.....	.....	10.95	7.40	14.67	1.1

Normal monthly, seasonal, and annual temperature and precipitation at Independence—Continued.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
June	75.6	105	45	3.24	3.83	11.65	0.0
July	80.7	111	54	4.32	3.15	1.50	0.0
August	79.8	111	43	3.15	4.59	2.53	0.0
Summer	78.7	.....	.....	10.71	11.57	15.68	0.0
September	72.2	109	34	3.93	0.72	4.36	0.0
October	60.2	95	24	2.94	1.48	12.54	T.
November	46.0	86	− 4	1.94	2.57	5.92	0.5
Fall	59.5	.....	.....	8.81	4.77	22.82	0.5
Year	57.5	111	−23	35.95	26.54	60.29	10.3

Average date of first killing frost in autumn, Oct. 24; of last in spring, Apr. 13.

It will be seen from the table that there is a wide range of temperature from season to season and from month to month. There is, moreover, as in most of the inland States, considerable range from day to day and from day to night. The very low temperatures are due to the cold waves and blizzards which not infrequently cross the Central Plains. Extremely high temperatures usually occur during the prevalence of "hot winds," which, blowing from southerly directions over heated ground, become very hot and dry. These winds usually are not of long duration.

The average precipitation of nearly 36 inches has a distribution very favorable for crops, since over half of it falls during the growing season. The snowfall of over 10 inches is a useful factor, for it protects wheat and grass from excessive freezing and by its slow melting sinks into the ground, thereby adding to the good supply of soil moisture. Many of the summer rains are local. Summer droughts occasionally occur, but there has never been a complete crop failure due to this cause.

The relative humidity of eastern Kansas is about 70, which is somewhat below the average of that of the United States as a whole. The dry air of eastern Kansas makes both cold and heat more easily endured, and men and horses work at high temperatures here which would be prostrating in a more humid climate.

The summer winds of this part of the State have a general southwesterly direction and are brisk, especially during the day. These winds, together with the low relative humidity and high percentage

of sunshine, favor rapid evaporation from soils and plants. Consequently the conservation of soil moisture often becomes important, even when there has been a fair rainfall. For this reason drought-resisting varieties should be cultivated, especially on the porous soils. The average frost-free season between April and October is long enough for the principal crops, and it is even longer in the more hilly districts, where fruits may profitably be grown.

AGRICULTURE.

The period of ranching was of short duration in Montgomery County, since the land was early divided into farms. The ranches were small and located not far from streams that could supply water in dry summers. The settlers homesteaded some of the land, but much of it was purchased from the railroads.

The most important crops of the country are corn, oats, and wheat. Corn is the leading crop, both with respect to value and to acreage. In 1912 there were 50,198 acres devoted to this crop, producing 803,168 bushels, or an average of 16 bushels per acre. While this is an unusually low yield, the ordinary yield per acre is by far too low and often on some soils does not repay the cost of cultivation. The crop does best on the loams, and on the Verdigris silt loam yields of 75 bushels or more per acre are not uncommon. Corn is sensitive to moisture conditions and suffers damage if the rainfall is insufficient during the growing season. As a whole this is probably the most efficiently handled crop in the county. It is usually well cultivated, and in dry weather a surface mulch is kept to retain the moisture in the soil. The ears are as a rule pulled from the stalks, which are turned under after cattle have been allowed to browse in the field. By this method a considerable portion of the fodder is wasted, both for feed and for manure. The principal varieties grown on the uplands are Bloody Butcher, Calico, and Hickory King. The Boone County White is largely grown on the bottoms, and to some extent on the uplands.

Kafir is rapidly coming into favor, especially on the sandy soils. It is hardy, stands dry weather well, and is perhaps the surest crop grown. It is much more certain than corn. Besides the grain, it affords good forage, and its extensive cultivation will enable the keeping of a larger number of live stock, which is much to be desired. In 1912 there were 22,847 acres of kafir—an acreage double that of the preceding year. The production of forage was 46,694 tons.

Next to corn, oats are the most valuable crop in the county, 755,038 bushels having been produced from 22,207 acres in 1912. The crop does fairly well on most soils. There are occasional failures resulting from adverse seasonal conditions, but even in such cases the

crop yields good hay. It seems especially adapted as a money crop for the sandy soils. The Red Texas variety is in wide use. Under normal conditions 40 bushels is a fair average yield, and much higher yields are not uncommon.

In 1912, 17,079 acres were devoted to wheat, producing 222,027 bushels, or an average of 13 bushels per acre.[1]

The average for the State as a whole was 14 bushels per acre. Winter wheat is grown almost exclusively, being better adapted to the climate and soils of this section than spring wheat. It can be grown with less labor than most crops, and there is usually a ready market for it at fair prices. The favorite varieties are Harvest Queen, White and Red Fultz, and Red Seal.

Where the land has been continuously planted to wheat year after year there has been a decline in the average yield per acre of this crop. The acreage and yield have also been reduced by the ravages of the chinch bug.

Rye and barley are grown only to a limited extent.

Sorghum is another hardy, drought-resistant crop that is coming into favor. In 1912 there were 4,329 acres sown for forage or grain and 186 acres for sirup, an acreage almost double that of the preceding year. There are many small mills where sirup for home use is manufactured.

There is probably more interest at present in the culture of alfalfa than of any other crop. According to the census, 8,534 tons of hay were produced from 3,515 acres in 1909. Since then the acreage has been greatly increased, especially on the bottom soils, and the crop is being tried on the uplands. Yields of 4 tons or more to the acre are not uncommon on the alluvial soils, and good yields have been made on the heavier upland soils. As a rule the crop is well handled. The seed bed is usually well prepared, but frequently the plowing is too shallow. With proper treatment of the soil this crop would probably succeed on the loams and silt loams of the uplands. Liberal applications of manure, thorough preparation of the seed bed, and probably soil or seed inoculation will be necessary. The soil should also be tested for acidity. The main causes of failure on favorable soils are poor drainage and insufficient preparation of the seed bed. This crop usually leaves the soil in better condition than before; the roots penetrate deeply, loosen the subsoil, and bring up plant food, and the plant has the power to take nitrogen from the air and fix it in the soil. The acreage devoted to alfalfa was increased from 3,786 acres in 1911 to 5,602 acres in 1912.

Considerable prairie hay is produced, the greater part of which is consumed locally. This hay is harvested mainly on the sandy soils.

[1] Most of the statements in regard to acreage and production of the crops given in this report are based on the reports of the Kansas State Board of Agriculture.

Cowpeas are grown in small areas over most of the county, but this important crop is not generally appreciated. The crop is hardy, will thrive where clover will not grow, and makes excellent hay. Like all legumes, cowpeas add nitrogen to the soil, and, when properly managed, leave the soil in better condition than before. They are an excellent crop for green manuring, and can be grown for this purpose after the crop of wheat or oats is harvested. Good yields of cowpeas have been obtained when sown in cornfields at the last cultivation.

Irish potatoes, both early and late crops, are a crop the possibilities of which have been overlooked. According to the 1910 census, 699 acres in 1909 produced 48,055 bushels of potatoes, an average of nearly 70 bushels per acre. The crop does especially well on the well-drained sandy lands. As a rule, not enough potatoes are grown in the county to supply the home market. This should be a profitable money crop on the Bates loam and the Bates very fine sandy loam, and probably also on the Verdigris soils. It might well take the place of wheat on these soils. Sweet potatoes do well on the warm, well-drained soils and have a ready market.

Montgomery County produces comparatively little orchard fruit, and the farmers seem discouraged and indifferent as to the outlook. Many small orchards have been set out on the Oswego silt loam and on soils of the Osage series—heavy soils with stiff, heavy subsoil. Most of the orchards on these soils are in poor condition; the root system is shallow and the roots spread out above the subsoil and are easily injured during dry spells. The Bates series is especially adapted to fruits where the soil is not too shallow, and there are some fine orchards of apples, peaches, and pears, as well as some vineyards, on these soils. The Summit clay, colluvial phase, the Summit loam, gravelly phase, and the Oswego loam, colluvial phase, are good fruit soils. Most of the orchards are poorly kept and little if any spraying is practiced. The orchards would well repay better attention, and fruit growing might be profitably extended on these soils. Grapes appear to do well on the sandy soils, but there are few vineyards.

Hogs are raised throughout the county in a small way, usually in connection with general farming. In 1912 there were 25,692 hogs in the county. The Duroc-Jersey breed predominates.

The number of beef cattle raised in the county is gradually decreasing. In 1911 there were 13,341 head of cattle other than milch cows reported, with a value of $360,207, and in 1912 there were 12,383 head, valued at $396,256. Some decline might be expected with the plowing of pastures, but with the present high prices this branch of agriculture offers good profits. The keeping of more live stock is also desirable from the soil improvement point of view, as practically all soils need the application of barnyard manure. The

principal pastures are on the Bates series and some entire sections in the south-central hilly areas of the county are used for grazing. A great many farmers have two farms, one on the heavier soils, where corn and alfalfa are grown, and the other on the lighter soils for pasture. The principal beef breeds are Shorthorns and Herefords and there is an increasing interest in good breeding stock. A large number of steers are shipped into the county to be finished for market, and this branch of the industry will probably be extended. The dry summer of 1913, which reduced the corn yields, led to the building of silos. Many more silos could be used.

The number of milch cows reported in 1911 was 11,271, with a production of 492,072 pounds of butter, valued at $118,097.28. This production fails by far to supply the local market. There are a comparatively few dairy farms which supply milk to the cities, and no creameries or cheese factories were seen in the entire county during the survey. Holsteins and Jerseys, both pure and graded, are the principal breeds on the dairy farms. Dairying undoubtedly offers the largest inducements, all things considered, of any line of agriculture in the county, since there is an excellent steady home market for dairy products. An emergency crop of rye, oats, or barley should be grown for use in dry seasons when pasturage is scanty. The problem of water for stock must also be met here as elsewhere. Alfalfa hay and corn silage afford excellent forage for the winter.

Breaking the ground for wheat and corn is done by plowing, listing, or disking usually in August and September. On the whole, plowing is too shallow, the usual depth being 4 or 5 inches, especially on the heavier soils. On the heavy soils of the Oswego silt loam and the Osage series it is difficult, if not impracticable, for a single team to plow below 5 inches, and the expense of deep plowing is avoided, as a rule, especially by tenant farmers.

Commercial fertilizers are very little used, and only in exceptional cases is stable manure carefully saved. Whether it would pay to use commercial fertilizers is a problem that will have to be worked out by experiment, but there is no doubt as to the need of manure. Green manure can be supplied by plowing under leguminous crops, such as cowpeas, which also furnish nitrogen to the soil. Much straw at present is burned which, if plowed under, would greatly benefit the soils.

Many, if not most, of the soils, especially the upland types, are somewhat sour. A cheap corrective is finely ground limestone or burnt lime. Lime tends to improve the tilth as well as to sweeten the soil.

So far as observed there is very little attempt at systematic crop rotation. Wheat and corn are grown for several years, and then

the land is put into pasture for a year or so. As a general rule rotation should include some leguminous crop like cowpeas or alfalfa. A rotation that has worked well on the Verdigris series is as follows: Wheat, one or two years, cowpeas, corn, oats. The crop rotation for the Osage series is yet to be worked out, but cowpeas or some other leguminous crop should be included. The same principle applies to the Oswego silt loam, but this will be discussed in more detail in the description of this type. The following rotation has been successful on the Bates series, viz, kafir, cowpeas, corn, oats. The same rotation, with the addition of a year or two of wheat, works well on the Crawford and Summit series. One of the necessary points in a rotation for the hard-used and sandy soils is to introduce a humus supplying crop like cowpeas.

Farm machinery is extensively employed, and the implements are, for the most part, modern. As yet traction machinery is but little used, although traction plows have been introduced within the last year and have given satisfaction. This machinery seems to meet the requirements of deeper plowing on the heavy lands.

A beginning has been made in levee construction to protect the lands subject to overflow along the Elk and Verdigris Rivers and their tributaries. Along the unprotected bottoms farmers expect to lose a crop once in 5 to 7 years, and the loss is often even more frequent. The crop losses alone soon equal the amount required to build levees.

A large proportion of the land of Montgomery County is arable. In 1910, 89.1 per cent of the total land area was in farms and 80.7 per cent of this was classed as improved. The average size of the 2,563 farms was 143.3 acres, 115.6 acres of which were classed as improved. The larger farms are on the sandy loams of the Bates series and are used for pasture. There seems to be little tendency toward smaller farms, except in the market gardening districts near Independence and Coffeyville. According to the census, in 1910 the average farm acre was valued at $32.36, as against $15.81 in 1900, an increase of over 100 per cent in 10 years, and the average value of farms was $6,670, the land and buildings being valued at $5,546.

The percentage of farms operated by tenants in 1910 was 42.6, and the ratio of tenant-operated to owner-operated farms seems to be increasing. Many farmers owning lands on the more productive soils and others having good incomes from royalties on oil and gas lands have retired and moved to the towns. Cash rents vary from $1.50 to $10 an acre, depending on the distance from towns and the suitability of the land for alfalfa and wheat. There are about three times as many share tenants as cash tenants. On the share basis, when the owner furnishes the seed, he receives one-half the crop, and when the tenant furnishes everything, one-third the crop.

The labor problem is serious. There is the drift to the city, so common in most rural districts, and, moreover, the many factories absorb much of the available labor. The result is that, except at harvest time, crops are planned, as far as possible, to be worked without hiring labor, and machinery is used wherever possible. Regular farm hands are paid $20 to $30 a month and board.

Drainage, especially underdrainage, is a problem on some of the soils, especially of the Osage and Oswego series, and of the Verdigris flood plain. The most important drainage project so far undertaken in the county is the construction of a canal in the Advance School District in Louisburg Township. It drains a large area of Oswego silt loam. The canal is being built by the farmers, and the expense is to be met by a flat tax on the district. Interest is aroused in the problem of drainage, and in all probability other canals will be built in a few years.

SOILS.

According to origin the soils of Montgomery County fall into three classes—residual, colluvial, and alluvial. The soils having been grouped in this way are further separated into series and types according to the source of their materials, their color, and their texture.

The residual soils, being derived from the decomposition of rock in place, are closely related to the underlying formations, which are exposed in Montgomery County in belts having a general northeast-southwest direction across the county. To a less extent the soils are also locally affected by formerly overlying rocks, the insoluble portions of which have remained at the place of disintegration. For example, the Oswego silt loam in some localities near the Buxton sandstone in the western part of the county retains sand from the previously overlying sandstone. Sandstone, shales, and limestones are the rocks in Montgomery County which have furnished the residual soils. Their general arrangement is shown in figure 2.

Sandstones and sandy shales are widely exposed, especially in the western part of the county, and generally yield the Bates series. The Buxton formation in the western part of the county contains much reddish sandstone, in which there is a large percentage of very fine sand and considerable clay. It is a well-cemented rock and in weathering breaks down into comparatively large blocks, forming the Bates stony loam. The Wilson formation contains much fine-grained sandstone, which is, as a rule, much less firmly cemented than the Buxton sandstone. For this reason it often weathers into smaller fragments and yields the Bates gravelly loam. There is some sandstone in the Coffeyville formation. For the most part the sandstones of the county yield the Bates very fine sandy loam.

Shales locally known as "mud rock" or "clay" occur largely in the Wilson and Coffeyville formations and to a less extent in the Buxton formation. They usually contain considerable fine sand and are extensively used for the manufacture of brick and tile. Interbedded with these shales are numerous strata of limestone, which locally modify the soils and often yield limestone soils of too small area to be shown on the map. The shale formations give soils grouped in the Oswego, Cherokee, and Gerald series.

The limestone of greatest surface exposure in the county is the Piqua limestone, from which comes the large area of Crawford soils

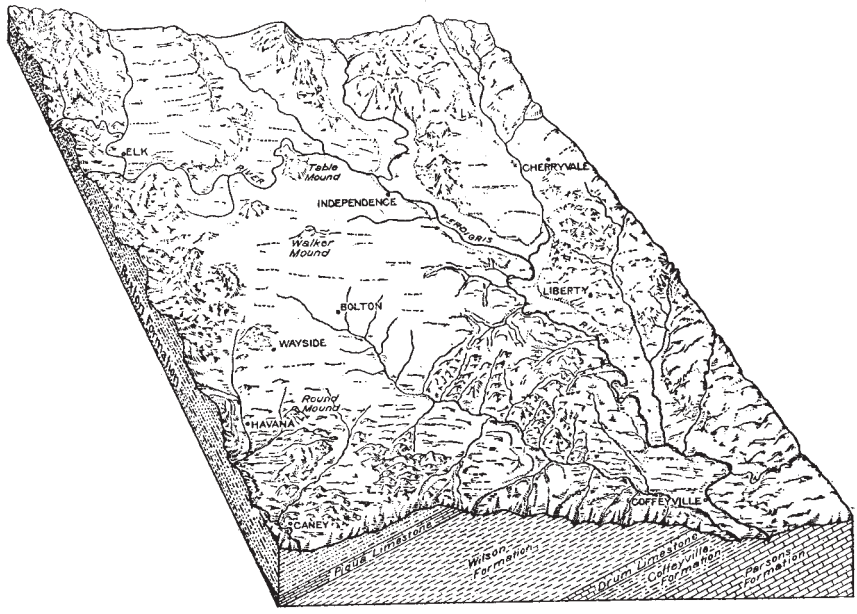

FIG. 2.—Relief map of Montgomery County, showing the main surface features and the rocks at the southern border.

in Louisburg and Sycamore Townships and the scattered areas of these soils to the southward. Another important limestone formation is the Parsons, which yields the limestone soils in the southeastern part of the county. The Drum limestone extends in a narrow belt from the vicinity of Cherryvale southwestward and leaves the county near Coffeyville. It lies between the underlying Coffeyville and the overlying Wilson formations. Usually the Drum limestone is more resistant than the neighboring shales, and therefore the areas underlain by this limestone are relatively high, with steep slopes, and the soils are somewhat stony.

There are two important limestone formations in the Coffeyville formation, the Mound Valley and Dennis limestones, which result in considerable areas of Summit and Crawford soils.

FIG. 1.—LOOKING NORTHWARD FROM WALKER MOUND.

[Gently undulating prairie on Oswego silt loam in middle distance. Elevation in background is Table Mound.]

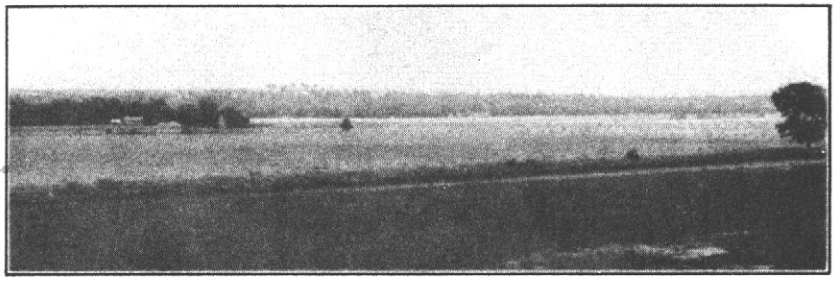

FIG. 2.—FLOOD PLAIN OF THE VERDIGRIS RIVER.

[Alfalfa in foreground on Verdigris silt loam; wheat in middle distance on Osage silty clay loam. Sandstone bluffs in background.]

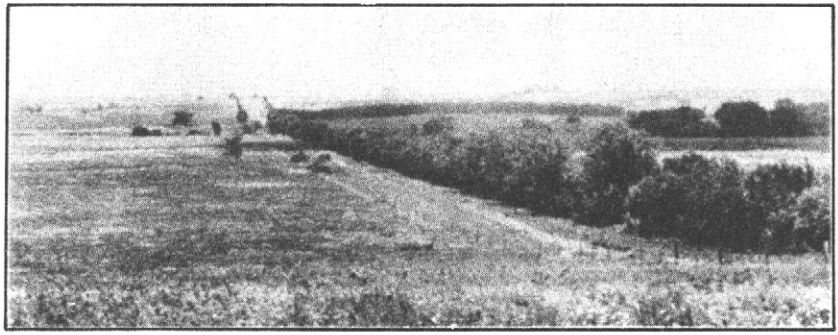

FIG. 3.—MOWING LAND IN HILLY COUNTRY NORTHEAST OF INDEPENDENCE. BATES VERY FINE SANDY LOAM.

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Most of the limestones are rather free from flint and chert impurities often found in such rocks, and in consequence they weather to fine-textured soils. There are considerable areas of stony soils associated with the sandstones and the limestones. These coarse soils are due not so much to the resistance of the rock as to the activity of erosion. While weathering tends to change the rocks to deep soils, the streams carry away the small particles. In consequence there is a gain of weathered materials in the level and rolling areas where the soil is deep because erosion is weak. On the other hand, in the hilly areas the preponderance of erosion over weathering gives the stony soils, because the finer soil particles are carried away.

Colluvial soils are formed by the action of gravity and local wash. The soils are loosened by freezing and thawing and by expansion and contraction, due to changes in temperature. Then there is the wash of surface water and the slower movement of subsoil water which carry materials down the slopes. The net result of these movements is a slow soil creep down slopes and the accumulation of material near the slope bases.

Two especially favorable locations for the accumulation of colluvial soils are near the bases of the escarpments formed by the Piqua limestone and the Buxton sandstone. Belts of colluvial soils surround the lower slopes of nearly all the isolated hills in the county. These belts of colluvial soils are narrow, seldom over half a mile in width. They are usually stony on their upper slopes and grade on their lower slopes into the surrounding soils. Two types were mapped: The colluvial phase of the Summit clay, occurring near the foot of limestone escarpments, and the colluvial phase of the Oswego loam, occurring near the foot of sandstone hills and escarpments.

Alluvial soils are deposited by streams. While not of large relative area, they are important soils in the county and are mainly found along the Verdigris and Elk Rivers and their main tributaries. The fine weathered materials from the limestones, sandstones, and shales to the north and northwest of the county are carried by the streams, especially during floods, and when the streams overflow the flood plains or "bottoms" some of the load is deposited because of the slackening current. As a rule, the coarsest materials are found near the streams where the current is faster and the finer silts and clays are deposited by less rapid water back from the streams. We therefore usually find loams and silt loams along the stream banks and clays and clay loams farther back. The alluvial soils of Montgomery County are dark in color and fine textured, even in the sandstone districts. They belong to the Osage and the Verdigris series.

The movement of soil water is always important from the viewpoint of drainage. It may also be important in one place from its work of leaching the soil and again as an agency of deposition. In a well-drained subsoil the color is likely to be reddish, as the better aeration caused by good drainage favors oxidation of the iron compounds which have become oxidized, while the subsoil of the same type in flat areas is likely to be grayish, owing apparently to lack of oxidation. In heavy subsoils iron and manganese compounds and gypsum are often deposited, this being especially characteristic in the Oswego, Cherokee, and Gerald series.

The following table gives the names and extent of the several soils mapped in Montgomery County.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Oswego silt loam	100,032	24.3	Summit stony clay	8,896	2.2
Bates very fine sandy loam	46,784	17.0	Summit silty clay loam	8,896	2.2
Shallow phase	23,104		Bates shale loam	6,528	1.6
Bates loam	49,664	12.0	Cherokee silt loam	5,888	1.4
Crawford loam	30,336	8.8	Bates gravelly loam	3,456	.8
Shallow phase	5,888		Summit clay	2,240	.8
Verdigris silt loam	24,704	6.0	Colluvial phase	1,216	
Bates stony loam	21,760	5.3	Gerald silt loam	3,008	.7
Crawford stony loam	16,768	4.1	Bates very fine sand	2,688	.6
Verdigris loam	14,784	3.6	Summit loam, gravelly phase	2,496	.6
Osage clay	11,584	2.8	Oswego silty clay loam	960	.2
Osage silty clay loam	10,304	2.5			
Oswego loam	1,280	2.5	Total	412,160	
Colluvial phase	8,896				

BATES SERIES.

The types in the Bates series are characterized by surface soils of a brown or dark-brown color, changing gradually to subsoils of yellowish or reddish-brown or mottled reddish and yellowish colors.

This series occurs in the Prairie Plains, where it is derived from the interbedded shales and sandstones of Coal Measure Age. In Montgomery County the soils are locally known as "sandy soils" in distinction to the heavier soils, although in regions having a wider distribution of sandy soils they would not be considered conspicuously sandy.

The following types were mapped in Montgomery County: Very fine sandy loam, loam, stony loam, gravelly loam, very fine sand, and shale loam. The main areas of these soils are the hilly district between Independence and Coffeyville and the broken areas underlain by the Buxton sandstone in the western part of the county.

BATES VERY FINE SANDY LOAM.

The Bates very fine sandy loam, which has the largest extent of the light soils in the county, is typically dark brown in color, although it may vary from brown to almost black, in the surface 6 or 8 inches. Below this the color is yellowish brown or light brown. Although the percentage of sand is high, the sand is so fine as to be almost imperceptible to the touch, and when the soil is wet its silt and clay content makes it seem heavy. Typically the subsoil is a reddish-brown to mottled reddish and yellowish friable fine sandy clay. It often varies in a few rods from a loamy fine sand to a fine sandy clay. In places the lower subsoil is mottled ocherous yellow, reddish yellow, and black. The subsoil lies from about 8 to 20 inches below the surface and often contains fragments of sandstone or shale, the quantity increasing with depth. Bedrock is frequently reached within 3 feet of the surface.

This type is distinctly a hill-land type, the surface always having marked slopes. Owing to these slopes the surface drainage is good. The porous character of the soil and subsoil insures good underdrainage. Erosion is excessive in places where slopes are steep. The type is derived mainly from the decomposition of sandstone and sandy shales, but in some places where the bedrock is shale and the slopes are steep the sandy character of the soil is due to erosion, the silt and clay having been removed and the sand left. Probably four-fifths of the type is under cultivation, but the more hilly areas are usually in stunted oaks. Plate 1, figure 3, shows an area of mowing land on this type northeast of Independence.

Oats and corn are the main crops on this soil, with kafir showing a rapid increase in acreage. The excellent drainage, warmth, and easy tillage allow early sowing of oats, so that, as a rule, the crop has a good stand before the dry weather to be expected later sets in, and often a yield of 40 bushels or more to the acre is obtained. Corn does well in normal years, but the average yield is probably less than 40 bushels. Kafir in most cases does well.

The type is an excellent truck soil, and is extensively used for this purpose near Independence and Coffeyville. Apples and peaches thrive, but the orchards are generally somewhat neglected. Were more care given the trees, fruit growing could be carried on successfully.

A great need on this type is a higher humus content, and this can be secured by plowing under cowpeas as a green manure, and also by the use of barnyard manure. Frequently cowpeas have been sown at the last cultivation of corn. As an all-around fertilizer nothing can compete with stable manure. This could be obtained by an

increase of dairying and cattle raising, for which the soil is well adapted.

While no extensive tests were made, yet in every case where the soil was tested it was found to be acid. This condition indicates the need of lime, which can be applied in the form of ground limestone or in other forms. Alfalfa has not been given a fair trial as yet.

Where favorably situated for truck farming near a city this type has sold for $100 an acre, but the average is about $40, with the more broken land selling around $15 an acre.

Bates very fine sandy loam, shallow phase.—The Bates very fine sandy loam, shallow phase, has been mapped in general where bedrock is found within 10 inches or less of the surface. The soil resembles that of the main type, but a distinct subsoil is usually lacking. Sandstone fragments are common Such areas naturally have a low agricultural value. They are mainly used for pasture, although good crops of oats have been grown by careful tillage. Early truck crops would doubtless do well. The soil occupies positions on hilltops and on steep slopes where erosion is active.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the typical Bates very fine sandy loam:

Mechanical analyses of Bates very fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381405	Soil	0.6	1.2	0.6	3.4	60.4	24.1	9.6
381406	Subsoil	1.4	1.5	.5	1.0	27.0	54.7	13.9

BATES LOAM.

The Bates loam is a brown to dark-brown mellow loam, underlain at 6 to 8 inches by a yellowish-brown loam, which passes at 10 to 18 inches into the subsoil proper, consisting of sandy clay, usually of a reddish-brown or mottled reddish-yellowish color. There are in places some sandstone fragments, and bedrock occasionally is reached within the 3-foot section.

This type has a wide distribution over the county and is well esteemed as a corn and wheat soil. It occupies level to rolling areas and is usually found on lower slopes of hills and ridges where there has been some soil creep of the finer particles. The type is closely associated with the Bates very fine sandy loam and the boundary line between the two is usually somewhat arbitrarily placed. For the most part the surface and subsoil drainage is good and artificial drainage is seldom necessary.

This type is one of the best general-purpose soils in the county. It produces good yields of corn, wheat, and oats. It is easily worked and crops can be put in early. This type is somewhat deficient in humus, a deficiency that can be remedied by plowing under stable manure or green crops, especially cowpeas. It is a fairly good fruit soil, and with better care the orchards would undoubtedly pay well. Alfalfa with careful management might prove a successful crop.

Land of this type of soil ranges in value from $30 to $50 an acre.

BATES STONY LOAM.

The Bates stony loam is a brown to dark-brown loam, typically underlain at a depth of about 6 to 8 inches by a light-brown, yellowish-brown, or reddish-brown loam, which quickly passes into red or mottled red and yellow friable sandy clay. Rock fragments are found in the soil and subsoil, and bedrock is usually reached at 15 inches or less. The sandstone fragments are rounded by weathering and vary in size from small pebbles to large bowlders.

This is characteristically a hilly soil type and is found most extensively in the western part of the county, where it occupies the sandstone hills of the Buxton formation.

The type is usually uncleared and covered with blackjack oak, which is seldom large enough for lumber. From some of the smoother, less stony areas, wild hay is cut, but such areas are usually pastured. A considerable number of sheep and goats are grazed on this type and this is probably the best use for it. It is seldom sold separately, but its average value is probably not more than $5 an acre.

BATES GRAVELLY LOAM.

The Bates gravelly loam is a brown to dark-brown gravelly loam or very fine sandy loam, underlain a few inches below the surface by a subsoil of heavier texture, usually a loam, and of reddish or yellowish color. Both soil and subsoil are of open texture. Small fragments of sandstone are plentiful on the surface and usually increase in number until bedrock is found at about 20 inches or less. The usual position of the type is on hilltops and ridge crests.

This type corresponds in origin and position to the Bates stony loam and occurs over the weaker sandstones and sandy shales of the Wilson and Coffeyville formations; the sandstone here, being less strongly cemented, weathers to pebbles instead of bowlders.

This soil occurs only in small areas and is of low agricultural value. It is largely in pasture, and owing to its liability to erosion it should not be cultivated.

BATES VERY FINE SAND.

The Bates very fine sand is the extreme sandy type of the county, the soil varying from a gray to brown very fine sand. The subsoil lies at about 8 inches and varies from a very fine sand to a loamy very fine sand, of yellowish-brown to reddish color. Bedrock is usually found within 20 inches of the surface.

The type is derived from sandstone and sandy shales, and usually occurs on hilltops and on slopes where erosion has removed the silt and clay, leaving the fine sand usually intermixed with some gravel. A rolling area near Spring Hill Church in Parker Township appears to be due, not to elimination of the fine soil particles by wash, but to the presence here of a more sandy phase of the sandstone from which the type is derived.

This is a shallow, warm, well-drained soil, but, obviously, with small power to retain moisture. But a small proportion of its area is cleared, most of it being covered with blackjack oak, whence the common local name, "blackjack land." Between Dearing and Coffeyville a considerable acreage has been devoted to melons, cantaloupes, and cucumbers, which are very successful crops on this type. The soil is very low in humus and where cultivated means must be employed to supply this deficiency. It is a profitable truck soil where there is an accessible good market, but most of it should be left in pasture, the timbered areas being utilized for sheep.

BATES SHALE LOAM.

The surface soil of the Bates shale loam is somewhat variable, ranging in texture from a light to a heavy loam, usually brown or dark brown in color. The subsoil is likewise variable, ranging from a reddish heavy loam to sandy clay loam. The soil generally contains quantities of shale fragments, which increase in size and number with depth until bedrock is found, usually at about 20 inches.

This type occurs mainly in two localities. North of Coffeyville the Drum limestone includes a shale member which outcrops on the hillsides near the Verdigris River, forming steep slopes and yielding this type. A larger area is in the northern part of the county where the bedrock is largely shales of the Coffeyville and Wilson formations. Here the shale loam occurs only where erosion on slopes is more rapid than weathering; on less eroded topography the weathered shale would yield a heavy soil, such as the Oswego silt loam.

The soil is of little agricultural value and is naturally easily subject to erosion. On thick accumulations near the bases of hills fair crops of Kafir are grown and some fair apple orchards were observed. Most of this soil is in pasture and should be used for this purpose.

Oswego Series.

The Oswego series is characterized by dark-gray to black soils, and dark-brown to yellowish compact tough clay subsoils. The material is residual from shale. These are prairie soils, and the topography varies from gently undulating to rolling. Such a topography usually affords good surface drainage, but the heavy subsoil and low slopes make the underdrainage rather poor.

Three types of the Oswego series were mapped—the silt loam, loam, and silty clay loam. A colluvial phase of the loam was also mapped. The series is one of the most important in the county.

OSWEGO SILT LOAM.

In its typical development the Oswego silt loam is a dark-gray to black silt loam underlain abruptly at about 8 to 10 inches by nearly black or very dark brown heavy clay. The texture of the subsoil does not change with depth, but the color usually becomes slightly mottled with yellowish brown and, in the lower part of the 3-foot section or below, a yellowish-brown color. On slight elevations the color of the surface soil is somewhat lighter than that of the typical soil, which occurs on flat and generally level areas, being in some places a dark brown or dark grayish brown. In such areas the soil may be underlain by dark grayish brown silty clay loam, which quickly passes into typical tough nearly black clay. Occasionally the subsoil is slightly mottled with reddish yellow, but such areas are not typical. Small black concretions are frequently present in the lower subsoil.

The type has level to gently undulating topography, occupying the "level prairie," as it is usually called (see Pl. I, fig. 1). Owing to the nearness of the tough subsoil to the surface the type is also often known as "hardpan land," or in areas where the subsoil has been exposed by erosion "spotted hardpan land." The soil is derived from the decomposition of clay shales and sandy shales. Where derived from the former the soil and subsoil are much heavier than from the latter. This type is the most extensive level or smooth prairie soil in the county.

Owing to the shallow soil and impervious subsoil, the type does not absorb and hold moisture well, and in rainy seasons the same factors are responsible for poor drainage. Drainage is, therefore, an important problem. Tile drainage would probably improve it. In a few instances it has been tried and has been satisfactory.

At present the type is plowed only to a depth of 3 to 5 inches. Such shallow plowing is due in part to the fact that the land is usually broken in the late summer when the ground is dry and in part to the fact that the soil is stiff and difficult to handle at any

time. This shallow plowing is persisted in despite the fact illustrated in every neighborhood that deeper plowing has resulted in larger yields, in some cases increases of 100 per cent having been noted. Finely ground limestone has been very beneficial on this type; the lime corrects any acidity, and, moreover, causes the heavy soil to granulate, thus improving the tilth.

There is a deficiency of humus in this soil. This can be supplied by growing cowpeas, by green manuring, or by plowing under stable manure. Cowpeas do well if the seed bed is well prepared. Wheat straw has been turned under with good results.

The Oswego silt loam is prized as a wheat soil, and much of it used for the production of this crop. The yield per acre varies from 10 to 30 bushels, with an average of about 18 bushels. While under favorable conditions the soil is strong and will return good yields of wheat, the yields are diminishing because of continued cropping without replenishment of the organic supply. There are numerous instances of fields which have been in wheat 20 years or more. Rotations including leguminous crops like cowpeas or soy beans will improve the soil and at the same time bring in an immediate return of hay. Rotations including one or more years in pasture have been found to increase the yield of wheat on this land.

Kafir is not much grown on this type, but it has given satisfactory yields and is coming into favor, both for forage and for grain. The yields are best in the rolling, well-drained districts. Sorghum on the rolling areas especially is a good crop, being used mostly for forage, with yields of from one-half to 2 tons per acre. Oats do fairly well with favorable rainfall, the yields ranging from 15 to 40 bushels per acre. Corn is rarely good on the poorly drained areas, but yields from 20 to 40 bushels on the lighter textured, well-drained areas.

Alfalfa has been tried on many farms which include this type, but the results are somewhat indecisive as yet. There have been many failures to secure a good stand, and frequently the stand has thinned out in a year or two. Some of the failures are due to a poor seed bed, others to a drowning out in wet seasons, and others to excessive drying and cracking of the soil in dry seasons. On the whole the crop has been more a success than a failure. The returns from a good crop of alfalfa will justify every reasonable preparation. Liberal applications of lime or ground limestone and good drainage are essential on wet, sour land. The crop is much more likely to succeed on a thoroughly pulverized, heavily manured seed bed.

Cowpeas do well and should be more widely grown. Fruit trees do not thrive as a rule on this type and most of them are in poor

condition; the roots do not penetrate the subsoil, but form a shallow system which is easily injured by dry weather.

Land of this type varies in value from $35 to $60 an acre.

OSWEGO LOAM.

The soil of the Oswego loam is a dark-brown or almost black mellow loam, underlain at 8 to 10 inches by a yellowish-brown, heavy, sticky clay, well mottled with reddish brown.

This type occupies a few small scattered areas in valleys near the foot of sandstone hills with a rolling or undulating topography. The soil seems to be derived in places from the decomposition of somewhat sandy shales, but in many instances it seems to be due to soil creep from sandstone hills over heavier soils which now constitute the subsoils.

It is valuable for pasturage and where smooth enough for hay, corn, wheat, cowpeas, and the other general farm crops of the region.

Oswego loam, colluvial phase.—Typically the soil of the Oswego loam, colluvial phase, is a brown loam, but the color varies from light brown to dark brown, the latter color usually being associated with the heavier texture. Often there are sandstone and shale fragments scattered through the soil. Underlying at a depth of from 10 to 18 inches is a brown, plastic clay subsoil. This soil lies in narrow belts near the foot of sandstone and shale hills and is due to the soil creep on the hill slopes. Some small areas of sandy loam are included with this phase.

This land is highly esteemed for its good tilth and drainage and is a productive soil. In cases where a farm includes this soil and the Oswego silt loam the farm buildings and orchards are usually located on the Oswego loam. Corn and oats do especially well, but wheat gives only fair yields. Owing to its texture and position this soil is subject to erosion and considerable areas are badly gullied.

Mechanical analyses of samples of the soil and subsoil of the typical Oswego loam are given in the following table:

Mechanical analyses of Oswego loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381425	Soil	0.0	0.6	5.9	34.1	7.9	33.5	18.1
381426	Subsoil	.4	.8	4.4	30.4	6.9	30.1	26.7

OSWEGO SILTY CLAY LOAM.

The Oswego silty clay loam is a dark-brown to black silty clay loam, plastic when wet and tending to form pellets and crack open

when dry. It is locally known as "gumbo." The upper 3 inches is often silty. At about 8 to 15 inches occurs a heavy subsoil of dark-brown or black stiff clay, faintly mottled with rusty brown. This type is found in a small area southeast of Table Mound. The surface is low and the drainage, both surface and subsurface, is decidedly poor. It is a strong soil, however, and when plowed under right conditions good yields of wheat are obtained.

Below are given the results of mechanical analyses of samples of the soil and subsoil of the Oswego silty clay loam:

Mechanical analyses of Oswego silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381431	Soil	0.2	0.5	0.9	6.6	10.6	60.8	20.5
381432	Subsoil	.1	.4	.4	2.6	11.4	67.0	18.2

CHEROKEE SERIES.

The Cherokee series includes soils of gray color, and subsoils of dark-brown, heavy, impervious clay. The soils of this series are derived through weathering, from shales and sandy shales, and are invariably found in relatively low, level areas of deficient drainage. They are not extensively developed in Montgomery County.

CHEROKEE SILT LOAM.

The Cherokee silt loam as typically developed is a light-gray silt loam, of floury structure when dry, and slightly plastic when wet. The soil changes rather abruptly at a depth of 8 to 10 inches to the subsoil, which is a dark-brown, heavy clay, faintly mottled with gray and yellow and occasionally with reddish colors. The subsoil is practically identical with that of the Oswego silt loam. The tendency of the subsoil is to become heavier in texture and lighter in color with increasing depth. The area at the base of the sandstone hills in Louisburg Township is somewhat lighter in texture and color than the typical soil.

The type, so level that it is sometimes called "flat land," varies from nearly flat to gently undulating and is nearly always somewhat depressed below the adjacent country. In hilly regions it often occupies basins surrounded by hills. Here the surface drainage is naturally poor, and because of the nearly impervious subsoil the underdrainage is deficient. On the areas drained by open ditches, wheat and grass are noticeably better near the ditches. This would seem to indicate that underdrainage would pay. Where the soil is shallow and the subsoil has been turned up and cropped the yields have been

low for some time; it would probably be better in such cases to follow the plow with a subsoiler. Lime should be applied to loosen the soil and to correct any acidity.

This type is considered a fair wheat soil. The yields vary from 15 to 20 bushels of wheat; with favorable rainfall oats yield from 20 to 40 bushels. Corn is seldom a good crop and kafir is only a fair crop. Much of the type is in pasture. The values range from $20 to $40 an acre.

Mechanical analyses of samples of the soil and subsoil of the Cherokee silt loam follow:

Mechanical analyses of Cherokee silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381433	Soil	0.6	1.2	2.6	11.3	14.0	60.0	10.5
381434	Subsoil	.4	1.4	1.4	5.6	7.0	55.2	28.9

GERALD SERIES.

The types of the Gerald series are characterized by brownish surface soils and dark-brown heavy, waxy clay subsoils. The series is closely allied to the Oswego series, being derived from sandstones and shales, but the material forming the soils is lighter in color than in the case of the Oswego. The silt loam is the only type of this series mapped in the present survey.

GERALD SILT LOAM.

The surface soil of the Gerald silt loam consists of 5 to 10 inches of a brown floury silt loam. The immediate subsurface in places is a brown somewhat friable silty clay loam with grayish mottling which changes at about 20 inches into dark-brown tough heavy clay. In other places the heavy clay subsoil is found just beneath the surface layer of silt loam. Below 25 inches crystals of gypsum and small black concretions are often found. In places the subsoil is mottled with reddish brown and drab.

The location of this type is in relatively low basins with level to undulating topography. It lies usually a little higher than the associated Oswego silt loam or is a little more uneven in surface configuration. The soil is derived from shales and sandy shales, together with some fine material brought down by soil creep from adjacent slopes; at least this colluvial admixture appears to be found in the Circle Valley region in Rutland Township.

This soil is not considered very productive, although some wheat has been grown, giving yields from 10 to 20 bushels an acre. It is

popularly believed to contain alkali in places, but no surface indications were found. The level surface and dense subsoil tend to poor drainage conditions. With good drainage, the land should give good crops. It should be handled in much the same way as the Oswego silt loam.

Summit Series.

The soils of the Summit series are dark gray to black with mottled yellow and gray subsoils. They occupy smooth and flat to sharply rolling prairies and are characteristically derived from clay shales and interbedded limestone. Their dark color and their origin lead to the local name "black limestone land." While their aggregate area is not large, they are widely distributed, especially in the regions underlain by the Wilson and Coffeyville formations. Three types and two phases were mapped.

Summit clay.

The Summit clay typically consists of a black clay, which quickly passes into tough clay of the same color as the soil, though yellowish brown and often faintly mottled with reddish brown. In some areas there is a thin surface covering of silty clay loam, but this is nowhere deep enough to alter the clay texture in plowing. The lower subsoil is lighter in color than the upper, being usually yellowish brown. Black iron concretions occur in the subsoil.

The type occurs typically in the upper portions of drainage courses, and usually changes to a stony phase in the lower drainage courses, where the slopes become steeper. Limestone fragments are frequently found in the subsoil, and bedrock is sometimes found within 3 feet. The areas are all small, and no instance was observed where an entire farm was composed of this type.

The Summit clay is regarded as a strong soil but difficult to handle. If plowed wet it drys in hard clods, which are difficult to pulverize, and, when dry, the ground is very difficult to plow. However, with sufficient exposure the soil crumbles to a good tilth. Much of the type is in pasture, and this, under present conditions, is a good use to make of it. There is usually enough moisture in the soil to support a good growth of grass in dry weather. Wheat has yielded from 12 to 25 bushels, and oats from 15 to 30 bushels. Corn does well on well-drained areas. Alfalfa ought to be a good crop if the soil is first put in good condition. Cowpeas are usually a good crop.

Summit clay, colluvial phase.—This is naturally a variable soil, but in the main it is a brown clay or clay loam underlain at variable depths by clay of light or dark-brown color. The phase is located in narrow belts, seldom half a mile wide, near the bases of limestone escarpments and hills. This soil is of colluvial origin, being derived from the creep of limestone and shale detritus down steep slopes.

From its origin the soil is necessarily of a mixed character, varying from place to place with the composition of the rock and the steepness of the slopes. There are usually three well-defined belts—the upper stony belt, the middle belt of clay and clay loam, and the lower belt, which grades into the soils lying well below the escarpment. The topography always has a gentle slope from the escarpment, and it is usually gently undulating.

The middle and lower belts are very productive soils, yielding good returns of wheat, corn, and oats. Surface and underdrainage are excellent. The fine texture of the soil, together with the slope away from the escarpment, render the land especially subject to erosion. A gully, once started, is hard to check, except steps be taken in the early stages of formation. Wheat stubble will usually hold the soil against erosion, and rye or wheat or, even better, cowpeas in corn will help to hold the soil in place after corn is cut.

The stony belt is either covered with brush or is in pasture. Orchards do very well on this land, and are less likely to suffer from frost than in lower areas.

SUMMIT STONY CLAY.

The surface soil of the Summit stony clay is generally a dark-brown to black somewhat friable clay, underlain usually within a few inches, about 4 to 12, by bedrock. The surface is thickly strewn with thin limestone slabs, usually roundish, with a diameter up to 1 or 2 feet and a thickness seldom exceeding 6 inches.

The Summit stony clay is derived from limestone and is found on hill and ridge tops and along lines of active drainage where erosion exceeds weathering. The type includes many areas of rock outcrop too small to be shown separately.

This soil when cleared of rocks is productive, but is subject to erosion. Its best use is for pasture. Wild sweet clover grows abundantly and white and red clover have been very successful.

SUMMIT LOAM, GRAVELLY PHASE.

The Summit loam, gravelly phase, is a dark-brown to brown loam, usually containing a relatively high content of sand and a varying quantity of chert gravel. It changes gradually at from 8 to 15 inches into a subsoil of brown or reddish-brown clay or silty clay which usually contains angular or subangular flint pebbles.

The usual location of this soil is on hill slopes and the topography is commonly rolling. In the Coffeyville region this type is derived from a nodular limestone lying in the upper part of the Parsons formation, which contains many rounded flint pebbles. Some of the gravel on the more nearly level areas appear to have been deposited

by water, but these are usually too small to map. In other instances where the pebbles are rather angular they are evidently due to the decomposition of thin layers of flinty limestone.

This is a well-drained soil, both because of its topography and its somewhat open texture. It is an excellent fruit soil and there are many thriving orchards located on it. The warmth and good drainage also make it a good soil for the production of small fruits. Corn, wheat, and oats give fair yields. Owing to the steepness of the slopes this soil is somewhat subject to erosion and there are several gullied fields.

SUMMIT SILTY CLAY LOAM.

The Summit silty clay loam is one of the most distinctive types in the county. The soil is a black or dark-brown, somewhat friable silty clay loam from 8 to 15 inches deep. The subsoil is a dark-brown moderately crumbly clay, which grades below into mottled yellowish-brown and reddish-brown clay. The upper subsoil is frequently rather compact, but never so intractable as the corresponding portion of the Oswego soils.

The topography varies from nearly level to strongly rolling, but most of the areas have gentle slopes. The disintegration of limestone and interbedded shales yields the type. The areas are scattering, but are mostly found in the limestone districts underlain by the Wilson and Drum formations.

This is a productive soil, giving yields of wheat ranging from 15 to 25 bushels and of corn ranging from 25 to 50 bushels per acre. Good yields of alfalfa and cowpeas have been obtained. When plowed too wet the soil is lumpy, but the clods break up rather easily. Owing to the small scattered areas, the land is seldom sold separately, but the selling price ranges from $30 to $50 an acre.

CRAWFORD SERIES.

The Crawford series comprises residual soils derived from limestone and characterized by dark-brown to reddish surface soils and reddish subsoils. Owing to their color these lands are locally known as "red limestone lands." Two types are mapped in Montgomery County, the loam and the stony loam.

CRAWFORD LOAM.

The surface soil of the Crawford loam consists of 6 to 8 inches of dark-red or reddish-brown to dark-brown loam. The soil changes rather abruptly to the subsoil, which is typically a brick-red clay. This is mottled with yellow in places. In the lower subsoil, below 30 inches, small black and reddish-brown concretions are frequently

found. Many areas of silt loam and some areas of undifferentiated Gasconade soils too small to map are included in this type. Bedrock is seldom encountered within 3 feet of the surface.

In general the topography of this type is rolling or undulating, and it has good surface drainage and fair underdrainage. The largest area is that underlain by the Piqua limestone in Louisburg and Sycamore Townships. This limestone contains but little chert and yields a fine-grained soil with some quartz sand.

Most of this soil is under cultivation and it is considered one of the best general-purpose soils in the county. Wheat yields from 15 to 25 bushels per acre, corn 20 to 45 bushels, and oats 20 to 40 bushels. Cowpeas do well and there are many good stands of alfalfa.

Contrary to the general impression, some of the limestone soils, especially the deeper and less well drained phases, are acid, and before alfalfa is tried should be tested and limed if such unfavorable condition exists.

The selling value of this land has risen rapidly within the last few years. It now sells for $30 to $60 an acre, depending on improvements and nearness to markets.

Crawford loam, shallow phase.—The Crawford loam, shallow phase, like the Bates very fine sandy loam, shallow phase, is the result of an erosion so active that the products of weathering are removed nearly as fast as they are formed. It is a reddish-brown soil, seldom more than 8 to 10 inches deep, with many clay areas and many areas of stony loam too small for mapping. In fact this phase grades into the stony loam and the boundary between the two is usually indefinite. Its typical location is on slopes. The largest areas are adjacent to the Crawford loam in Louisburg and Sycamore Townships, but smaller areas are scattered over the county. It is a fair pasture soil and will afford a good growth of white clover. Land of this phase is seldom sold separately.

In the following table the results of mechanical analyses of samples of the soil and subsoil of the typical Crawford loam are given:

Mechanical analyses of Crawford loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381421	Soil	0.3	0.9	0.8	14.0	23.4	38.3	22.3
381422	Subsoil	.8	1.2	.8	9.7	19.4	36.7	31.6

CRAWFORD STONY LOAM.

The main characteristic of the Crawford stony loam is the abundance of limestone fragments ranging up to about 18 inches in diam-

eter in the soil. The fragments are usually thin, but in Cherry Township they have weathered to roundish shapes in places. The soil material varies in color from brown to red and in texture from loam to clay loam. In the deeper phases a reddish clay underlies the soil at 5 to 10 inches. Bedrock is usually found at less than 15 inches. In many places the soil has been eroded, leaving the clay subsoil at the surface.

The areas mapped in Montgomery County vary from very stony land that has no cropping value to land from which the stones have been so thoroughly removed that it could almost be mapped as the Crawford loam. Doubtless much of the better stony land remaining will eventually be cleared in the same way. The stony nature of this type, like the corresponding Summit stony clay, is due to an excess of erosion over weathering.

Much of the type is in pasture of native grasses and white clover.

Osage Series.

The Osage series includes alluvial types having dark-gray to black surface soils and subsoils. They are formed of materials washed from the shale, sandstone, and limestone soils of the prairie regions and occur in first bottoms subject to overflow. Two types, the clay and the silty clay loam, were mapped in Montgomery County.

Osage clay.

The soil of the Osage clay, locally called "gumbo" or "river gumbo," is a very dark brown to black stiff heavy clay or silty clay, very often extending to a depth of 3 feet, with little change in texture or color. In other places faint mottlings of reddish-brown, very dark blue, and yellowish colors are found in the lower subsoil.

The type is composed of fine materials deposited mostly in sluggish overflow water. The surface is almost level, but there is typically a slight slope away from the stream which gives fair surface drainage. Typically this soil occurs next to the uplands and away from the streams. It is most extensively developed along the Verdigris River and the lower courses of its tributaries where in times of flood the sluggish back water has deposited its load of fine-grained material.

This is a strong soil and is practically all under cultivation. Wheat is the favorite crop, with ordinary yields of 15 to 30 bushels and occasional yields of 40 bushels per acre. However, the yields are on the whole decreasing, many fields having been sown to wheat for 25 years with rarely an intervening crop. There are many fine fields of alfalfa on this type, but it is not always easy to get a stand. It is

difficult to prepare the seed bed thoroughly and drainage is likely to be deficient.

One of the great problems of such a heavy soil is that of securing a good tilth. When plowed in the right stage the soil falls apart in small granules. It is a common practice, especially by tenants, to plow only 3 or 4 inches deep. Among the reasons for this are the difficulty and expense of deeper plowing and the fact that if much of the subsoil is turned up the crop for the succeeding year or two is poorer. In some places a "plow sole" or artificial hardpan made by plowing to the same depth for many years was noted. Traction plows are in use with favorable results on a few farms on this type.

Lime in the form of finely ground limestone probably would increase the productiveness of the soil. It will improve the tilth and correct any acidity.

The values of this type are variable and range ordinarily from $35 to $60 an acre, some land in alfalfa and near good markets being held at prices around $80.

OSAGE SILTY CLAY LOAM.

The Osage silty clay loam is a dark-brown to dark-gray silty clay loam, underlain at 10 to 18 inches by a very dark brown clay or silty clay, often faintly mottled in the lower part with brown or reddish brown. This type is so closely related to the Osage clay that the difference is not commonly observed locally, and in many cases the boundary between the two types is so indefinite that the lines are arbitrarily placed.

Like the Osage clay, this type is found on the level first bottoms but somewhat higher than the Osage clay and nearer the streams. It is deposited by slowly moving currents in times of floods. The surface drainage is fair, but the subsoil drainage is generally poor. Tile drainage would undoubtedly repay the expense of its installation.

This soil when plowed under favorable conditions works into good tilth. It is a good wheat and oats soil (Plate 1, Fig. 2). Wheat yields from 15 to 25 bushels, oats from 20 to 40 bushels, and corn from 20 to 40 bushels per acre.

The value of land of this type is somewhat higher than that of the Osage clay.

VERDIGRIS SERIES.

The Verdigris series includes alluvial types lying along the streams in the Great Plains region and having brown soils and brownish subsoils. The material has been washed in part or largely from limestone, sandstone, and shale soils. These soils occupy first bot-

toms and are subject to overflow. The drainage, both surface and subsurface, is excellent. Two types—the silt loam and loam—were mapped. These soils are the brown equivalent of the Osage soils.

VERDIGRIS SILT LOAM.

The Verdigris silt loam is a brown silty soil, often containing a relatively large proportion of very fine sand. The subsoil is variable; in places, at depths of 10 to 18 inches, there is a gradual change to a brown or light-brown silty clay loam, which shows some grayish mottling in the lower subsoil. In nearly half the area of this soil there is but little change in the material from the surface to a depth of 3 feet, the soil and subsoil being essentially alike in color and texture.

The Verdigris silt loam extends almost continuously in a narrow belt, seldom over a half mile wide, along the Elk and Verdigris Rivers. The surface is relatively high and slopes very gradually from the streams back to the lower areas of Osage soils; it is level or gently undulating and very little cut up by streams. Naturally the drainage is excellent, the surface drainage because of the slope and the underdrainage because of the porosity of the soils. On the other hand, the soil is sufficiently fine of texture to retain moisture well, so that ordinarily there is not much trouble from drought. The main difficulty with this type is the danger of overflow, which can be removed only by levees.

This is the best corn soil in the county, yields of 75 bushels being common in favorable seasons. Wheat ordinarily yields 20 to 30 bushels and not infrequently 40 bushels per acre. Oats yield 30 to 60 bushels. Alfalfa does exceptionally well and yields from 1½ to 4 tons per acre (Pl. 1, fig. 2). The soil plows and cultivates easily and a good tilth is easily obtained.

Land values on the Verdigris silt loam range from $50 to $100 an acre, and areas near cities with good stands of alfalfa are held for $125 an acre.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of the Verdigris silt loam:

Mechanical analyses of Verdigris silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381447, 381449.....	Soil.....	0.0	0.1	0.3	7.9	19.5	54.1	18.1
381448, 381450.....	Subsoil.....	.1	.1	.4	8.9	16.9	55.0	18.5

VERDIGRIS LOAM.

The soil of the Verdigris loam is a brown loam, very friable, and often containing a relatively large proportion of very fine sand. The soil passes gradually at 8 to 15 inches into a variable subsoil, which is usually brown and a loam to sandy clay in texture. The lower subsoil in places is a dark-brown silty clay.

The type occurs in narrow belts along the front lands of streams where it was deposited by relatively swift currents at times of overflow. For this reason this type nearly always includes a belt of sandy loam which is too narrow to map. The largest continuous area extends along Onion Creek. In the small stream valleys of the sandy uplands this type includes soils which may vary from loam to very fine sandy loam.

This is a mellow, warm, well-drained soil. In normal years it produces from 40 to 60 bushels of corn and 20 to 50 bushels of oats per acre. The ready underdrainage of the type renders it somewhat droughty, but a surface mulch is easily maintained to lessen the effects of dry weather. Potatoes give good yields and small fruits and orchards do very well. Land of this type in fairly large tracts sells for $50 to $80 an acre, with higher values for truck lands near Coffeyville.

SUMMARY.

Montgomery County is located in the southeastern part of the State in the physiographic region known as the Prairie Plains. It contains 644 square miles, or 412,160 acres. In general the eastern two-thirds of the county is prairie and the western third hilly. Except for some of the river soils, the surface drainage is generally good.

Settlement has been comparatively recent, many of the pioneers still living in the county.

The development of oil and natural gas has increased the population and manufacturing interests of the county.

Railroad transportation is available to most parts of the county.

The system of wagon roads is ample and the roads are well kept.

Excellent home markets exist, there being a relatively large consuming population.

The summers are hot and the winters cold, and moderate rainfall. The mean annual temperature is 57.5° F. The frost-free season is usually long enough for most crops. The mean annual precipitation is 35.95 inches, over half of which occurs during the growing season.

Wheat and corn are the leading crops, the former usually being the main money crop. Wheat produces from 10 to 50 bushels and corn from 15 to 70 bushels per acre.

Oats and kafir are valuable secondary crops. The acreage of alfalfa is rapidly increasing. Potatoes do well on the lighter soils.

The production of beef cattle and dairying receive little attention. A large number of hogs are raised, but mostly for home consumption.

Nearly all of the soils need humus, and probably ground limestone could be applied with profit to most of them. There is but little systematic rotation of crops. All the soils would be benefited by a rotation including some leguminous crop. There are large areas of heavy soils that have deficient underdrainage.

Farm labor is scarce, and this has led to a wide use of machinery.

A large number of farms are operated by tenants, most of whom pay a share rent.

Land values range from $5 to $125 an acre.

The soils of the county include residual, colluvial, and alluvial types. Of the residual types the most important are the Oswego silt loam and soils of the Bates and Crawford series. The Oswego silt loam is a strong wheat soil. The Bates soils are mostly lighter textured soils, giving good yields of corn, kafir, and oats. The Crawford soils are reddish limestone soils. The loam of the series is considered the best general farming soil in the county.

The colluvial soils are productive but not of large area.

The alluvial soils fall in the Osage and Verdigris series. The Osage series includes two heavy types. They are productive but somewhat difficult to work. They as a rule need artificial drainage. The Verdigris soils are comparatively light, well drained, and probably the most productive soils in the county.

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[PUBLIC RESOLUTION—No. 9.]

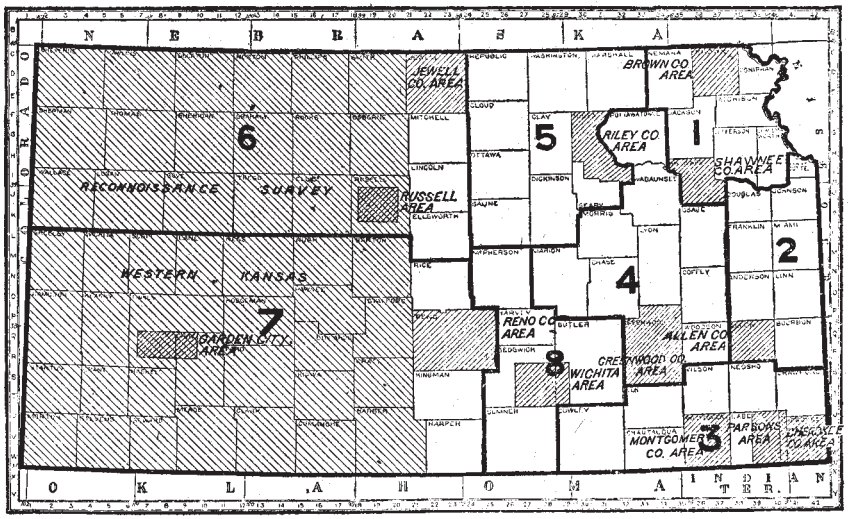
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]



Areas surveyed in Kansas.

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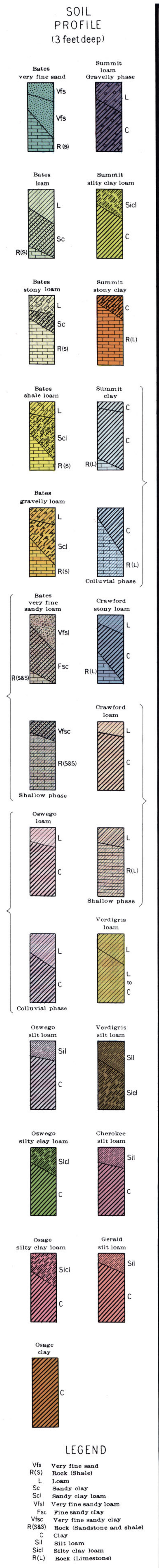
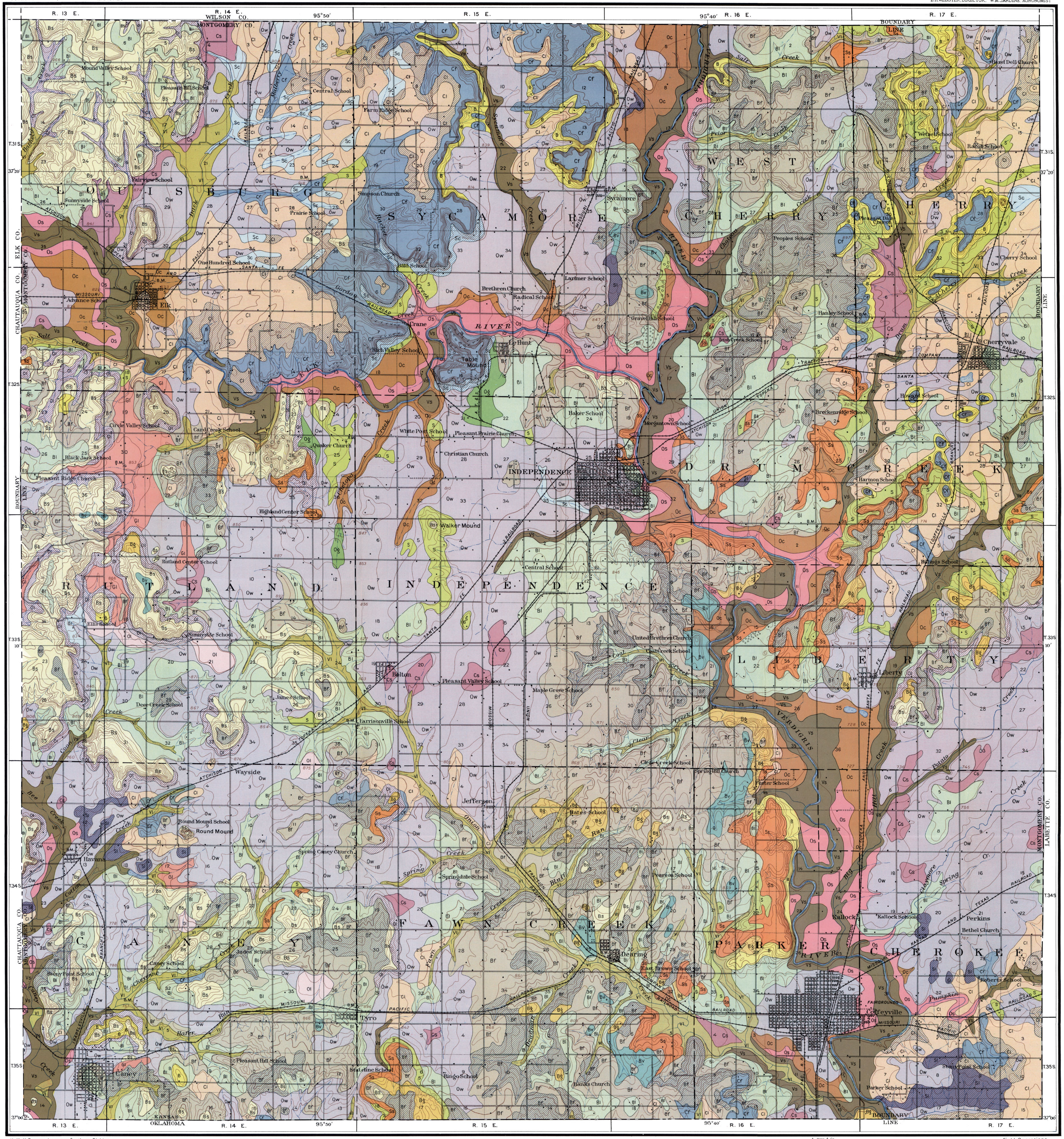
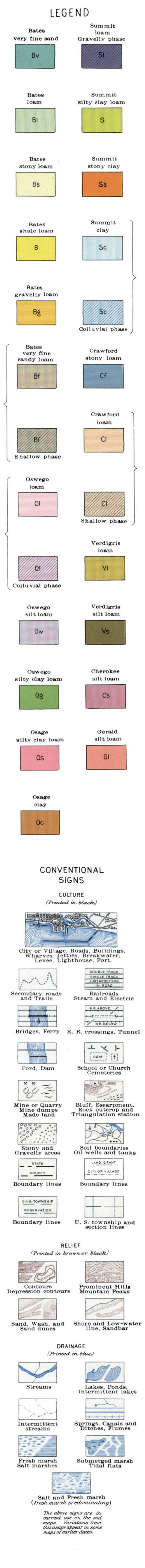
U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
KANSAS
MONTGOMERY COUNTY SHEET

KANSAS STATE AGRICULTURAL COLLEGE
H. J. WATERS, PRESIDENT
KANSAS AGRICULTURAL EXPERIMENT STATION
E. H. WEBSTER, DIRECTOR, W. M. JARDINE, AGRONOMIST







Hugh H. Bennett, Inspector Southern Division
Soils surveyed by F. V. Emerson, and C. S. Waldrop

BASE MAP FROM
U.S. GEOLOGICAL SURVEY SHEET

Scale 1 inch = 1 mile
Contour interval 20 feet

A. Hoen & Co.

Field Operations
Bureau of Soils
1913